Final Report, ONR 00014-67-C-0423, 9 August 1968

SPECTRA OF SOUTHERN GALAXIES

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During the last three years' duration of this grant, the following steps have been undertaken, as reported in previous interim reports (copies attached):

(a) During 1965-1966, the Cordoba Observatory 61-inch reflector at Bosque Alegre, Argentina, was renovated (with Smithsonian Institution support) so that my fast spectrograph could be used at the Newtonian focus. Over 50 spectra of galaxies were obtained, leading to several published papers by J.L. Sersic and his associates at the Cordoba Observatory.

(b) During 1966-1967, an image tube was obtained from the Carnegie Institution and substituted for the semi-solid Schmidt camera in the spectrograph. With this new combination, the spectra listed in Table 1 were obtained.

(c) During 1967-1968, the RCA Tube C was cracked during shipment to Argentina, and a new one has been purchased (cost: $5000). A Polaroid - Land camera was attached to the spectrograph so that the galaxy on the slit can be photographed before the spectrum is exposed. This allows identification of objects too faint to be seen in the eyepiece of the 61-inch reflector.

(d) During 1968, 12 spectra were measured by a graduate student assistant, using the Van Vleck measuring engine and microdensitometer, from which he wrote his thesis for a masters degree in astrophysics. He found that NGC 3783 is a Seyfert-type galaxy with high excitation lines.

The grant ONR 00014-67-C-0423 is closed out as of 31 July 1968, but further results from the spectra listed in Table 1 will be published and reprints forwarded to the Office of Naval Research.

Attachments: Table 1, Spectra of Southern Galaxies
Progress Report, January 1968
Progress Report, September 1967
1 Abstract
1 Final Report, November 1967 (copy not yet)

OBSERVATIONS OF SOUTHERN GALAXIES

Progress Report, ONR 00014-67-C-0423 8 January 1968

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Spectra of 51 galaxies have been obtained with the Fast Spectrograph at the Newtonian focus of the Cordoba 61-inch reflector, as shown in Table 1. Observing sessions in Argentina during February and July 1967 were successful; in December the Carnegie Image Tube was found to be broken, probably due to frequent transport between Middletown, Cambridge, Mass. and Cordoba, Argentina.

Improvements were made on the Fast Spectrograph with Schmidt camera during December: (1) a Polaroid - Land Film Holder was added so that the field can be photographed just before a spectrum is taken, and (2) an Xe Pen Ray lamp was added for comparison spectra.

Spectra of 5 galaxies were obtained with the Schmidt camera in the spectrograph, but most of these were under exposed due to hazy weather.

Another observing session is planned for July, 1968 for which I request Category Z transportation to Cordoba and return.

Thornton Page

Table 1. Spectra of Southern Galaxies, Feb. 1967 - Jan. 1968

NGC	Mag	Type	Plate Nos.	Radial Velocity	Comp. * Star	Remarks
625	12.6	SBc	C-422			Under
1511	12.5	Sa	IT-20	1480 km/sec		Em. line
1527	12.4	SO	IT-26	810		
1536	13.5	SBc	IT-23	1350		Em. line
I2056	12.7	SO	C-425			Em. line, under
1705	13.1	SO	IT-26	600		Em. lines, under
1796	13.2	Sb	IT-34	750		Em. lines
1947	12.4	SO	IT-16	540		Em. line
2397	13.1	SBa	C-423			under
2434	12.7	E0	IT-21	1180		
2888	13.8	E1	C-444			Under
3059	12.1	SBb	IT-34	940		Em. lines
3087	13.0	?				Under
3136	12.6	E4	IT-21			
	"	"	IT-23			
3223	12.0	Sb	IT-34	2450		
3257,8	13.1	ScE1	IT-33			One of a group
3268,71	13.0	E2SB0	IT-33			One of a group
3318	12.8	Sa	IT-32	2600		Em. lines
3783	13.1	SBa	IT-33	2800		Em. lines
"	"	"	IT-48		BS5288 K0	"
"			IT-58		BS4922 F2	Star under
4373,A	12.3	E3S0	IT-33			"A" = IC 3290
	"	"	IT-55		BS5089 G8	
4767	12.9	E5	IT-60			Under
I3896	13.0	E1Sbc	IT-72		BS7943 F1	
4835	12.7	SBc	IT-34	1800		Em. lines
4945	9.5	SBc	IT-35	~130		Em. lines
	"	"	IT-71		BS6855 M1	"

NGC	Mag	Type	Plate Nos.	Radial Velocity	Comp. Star	Remarks
5064	13.1	Sb	IT-58		BS4922 F2	Star under
5128	7.7	Ep	IT-48	470		Under
5365,8	12.8	SBO	IT-51		BS5580 F8	
			IT-52		BS5530 F8	Star over
5643	11.4	SBc	IT-60	1016	BS5698 F8	Em. line
5967	12.8	Sc	IT-52		BS5580 F8	Star over, Em. line
	"	"	IT-58		BS4922 F2	Star under
6221	11.8	SBb	IT-66			Em. line
I4662	12.0	Irr	IT-71		BS6855 M1	Em. line
6750	12.8	E1	IT-49		BS7674 F8	
"	"	"	IT-55		BS5089 G8	Under
"	"	"	IT-71		BS6855 M1	
6368,70	12.3	E2Sa	IT-72		BS7943 F1	
6984,2	13.3	SBcS	IT-53		BS6635 K2	Em. line, under
			IT-61		BS8368 F0	
7064	12.9	SBc	IT-63		BS7943 F1	Star under
7124	12.8	SBc	IT-56		BS7674 F8	Under
I5240	12.5	SBa	IT-53		BS8611 F0	
7205	11.7	Sb	IT-50			Fogged
7232	13.2	SBa	IT-61		BS8368 F0	Star over
7410	11.8	SLO	IT-47			
7412	12.0	SBb	IT-56		BS8700 G3	Em. line, star under
7421	12.3	SBa	IT-59		BS6635 K2	
7496	12.1	SBb	IT-73		BS8787 F6	
I5328	12.8	E5	IT-73		BS8787 F6	

* IT means image tube in Cordoba Fast Spectrograph
C means Schmidt camera in Cordoba Fast Spectrograph
BS means Yale Bright Star Catalogue number (followed by spectral type)
Radial velocities are preliminary values, uncorrected for solar motion.
Not all spectra have been measured.

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Spectra of Southern Galaxies. THORNTON PAGE *Harvard College Observatory, Smithsonian Astrophysical Observatory and Wesleyan University.*—During February 1967 a cascaded image tube on loan from the Carnegie Institution of Washington was installed in the fast grating spectrograph at the Newtonian focus of the Cordoba 61-in. reflector at Bosque Alegre, Argentina. With an $f/0.87$ Super Farron lens ahead of the photocathode, and an $f/1.2$ Elgeet transfer lens focusing the phosphor screen on Eastman IIaO plates, the definition is good from λ3800 to λ7800, the dispersion 294 Å/mm in the first order, and the speed increased by a factor of 5 over the original $f/0.5$ semisolid Schmidt camera used with Eastman 103aF film. Tests showed no shift in focus or position of spectrum due to nonuniform magnetic field in the steel dome. Using this image tube, spectra can be obtained of galaxies with surface brightness 14 magnitudes per square minute of arc in 30 to 60 min exposure.

Nineteen spectra were obtained of galaxies, and four of stars, together with calibration exposures in a step sensitometer. Microphotometer tracings show the preliminary results tabulated below. This work was supported by a grant from the Office of Naval Research, and was made possible by the Smithsonian Institution modernizing the Cordoba telescope.

TABLE I.

NGC	Type	Lines (equivalent widths)	Radial velocity (km/sec)
1511	Sa	Hα(6.0 Å)	1480
1527	S0	Hα(−7.2 Å)	810
1536	SBc	Hg(1.6 Å)	1350
1705	S0	Hα(20. Å), N_1(7.4), N_2(1.6), K(−0.6)	600
1796	Sb	Hα+[N II] (11.0 Å), [S II] (4.0)	750
1947	S0	Hα(0.7 Å)	540
2434	E0	λ7520 (7.2 Å), λ7680 (12.8)	1180
3059	SBb	Hα+[N II] (12.0 Å), [S II] (4.2)	940
3136	E4	(Absorption)	(810)
3223	Sb	Hα(−0.6 Å), Hβ(−0.6), λ5090(7.2), H(−2.1), K(−3.4)	2450
3257,8	Sc E1	(Peculiar)	...
3270,A	E2 SBv	(Absorption)	(200)
3318	Sa	Hα(4.8 Å), Hβ(0.5), Hγ(2.9), Hδ(−0.9),	2600
3783	SBa	Hα(80.Å), [S II] (1.1), N_1(17.3), N_2(13.2), Hβ(11.7), Hγ(9.9), λ7520 (2.9)	2800
4373,A	E3 S0	(Peculiar)	...
4835	SBc	Hα+[N II](13.2 Å), [S II] (1.9)	1800
4945	SBc	Hα+[N II] (12.3 Å), [S II] (1.7)	−130

Progress Report to ONR on N onr 14 67 6 0423, 20 Sept. 1967

SPECTRA OF SOUTHERN GALAXIES

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Since my report of 20 Mar. 1967, I have made another trip to Cordoba, Argentina, and obtained spectra of twenty-four more galaxies with the Carnegie Image Tube in the fast spectrograph at the Newtonian focus of the 61-inch reflector there. The list of galaxies and standard stars is given in Table 1. A graduate assistant has been learning how to use the Joyce-Loebl microdensitometer with which these spectra will be reduced, and has measured some of the spectra for redshifts.

Spectrophotometry on image-tube plates has the advantage that all parts of the spectrum are photographed in light of the same color (from the phosphor screen). Thus, only one characteristic curve need be used in reducing intensities from measured densities. The standard star spectra will be used to obtain the color sensitivity of the RCA C 33011 tube combined with the selective effects in the telescope and spectrograph optics. In order to equalize exposure time and broaden the stellar spectra, a piece of ground Lucite was placed in front of the spectrograph slit, and a number of spectra were taken to determine its selective absorption. Techniques are now being worked out for rapid conversion of density tracings to curves of intensity vs wavelength in galaxy spectra.

From 21 to 31 Aug. I attended the XIII Congress of the International Astronomical Union in Prague, Czeckoslovakia, attending all the sessions on galaxies held by Commissions 28, 33, 34 and 40. A brief report on Spectrophotometry of Galaxies with an Image Tube was presented at the Comm. 28 meeting (abstract attached), and a summary article has been written for publication in Sky and Telescope Magazine, Dec. 1967.

Table 1.

Image-tube Spectra of Southern Galaxies, Cordoba, Aug. 1967

NGC	Mag	Type	Plate Nos.	Comparison Star BS No.	Comparison Star Type	Remarks
3783*	$13^{m}.1$	SBa	48	5288	KO III	Em. lines
			58	4922	F2	Star underexp.
4373*,A	12.3	E3SO	55	5089	G8 III	
4767,A	12.9	E5SO	60	5136	KO	Star under
4945*	9.5	SBc	71	6855	M1 III	Em
5064	13.1	Sb	58	4922	F2	Star under
5128	7.7	Ep	48			Under exp.
5139		Glob Clust	62	(6563	Plan Neb)	
5365,B	12.8	SBO	51	5580	F8	
			52	5580	F8	Star over exp.
5643	11.4	SBc	60	5698	F8	Em., Star under
5967	12.8	Sc	52	5530	F8	Star over
			58	4922	F2	Star under
6221	11.8	SBb	66			Em. lines
6758	12.8	E1	49	7674	F8	
			55	5089	G8 III	Both under exp
			71	6855	M1 III	
6868-70	12.3	E2Sa	72	7943	F1 V	
6984-2	13.3	SBcS	53	6635	K2	
			61	8368	F0 IV	
7064	12.9	SBc	63	7943	F1 V	Star under
7124	12.8	SBc	56	7674	F8	Both underexp.
7205	11.7	Sb	50			Fogged
7232	13.2	SBa	61	8368	F0 IV	Star overexp.
7410	11.8	SBO	47			

NGC	Mag	Type	Plates	Comp. Star	Type	Remarks
7412	12.0	SBb	56	8700	G3 IV	Star under
7421	12.8	SBa	59	6635	K2	
7496	12.1	SBb	73	8787	F6 IV	
IC						
3896	13.0	E1SBc	72	7943	F1 V	
4662	12.0	Irr	71	6855	M1 III	Em lines
5150		Plan Neb	57			
5240	12.5	SBa	53	8611	F0	
5328	12.8	E5	73	8787	F6 IV	

* Repeats of 3 spectra obtained in Mar. 1967.
The 2 x 2-inch plates usually have 4 spectra on each.
"BS No." refers to Yale Bright Star Catalog.